EFFECT OF SHADING, MYCORRHIZA INOCULATION AND ORGANIC MATTER ON THE GROWTH OF Hopea gregaria SEEDLINGS*)

by Suhardi **)

INTISARI

Hopea gregaria merupakan jenis dipterokarp yang berasal dari daerah kering. Penanaman dipterokarp sering mengalami kesulitan karena hampir semua dipterokarp memerlukan naungan untuk pertumbuhan awalnya. Percobaan *H. gregaria* ini dilakukan dalam rangka upaya untuk dapat memecahkan persoalan penanaman dipterokarp langsung tanpa naungan.

Media untuk perkecambahan adalah tanah pasir steril. Media untuk sapihan adalah tanah asam steril. Percobaan ini dilakukan di dua tempat yang berbeda tingkat intensitas sinarnya yakni dengan cahaya penuh (*glass house*) dan dengan cahaya sebagian yakni sebesar 60 % cahaya masuk (*screen house*). Perlakuan di masing-masing tempat terdiri atas perlakuan pemberian bahan organik dengan 4 tingkat, perlakuan inokulasi 3 tingkat dan perlakuan dengan arang sekam 4 tingkat.

Dari hasil analisis varians dapat ditarik kesimpulan bahwa percobaan di tempat cahaya penuh memberikan pertumbuhan yang jauh lebih baik dibandingkan dengan tempat dengan cahaya masuk sebagian. Bahan organik memberikan pengaruh nyata terhadap pertumbuhan diameter. Arang sekam padi mempunyai pengaruh nyata terhadap pertumbuhan diameter tetapi tidak berpengaruh nyata terhadap pertumbuhan tinggi. Inokulasi berpengaruh nyata terhadap pertumbuhan tinggi tetapi tidak berpengaruh nyata terhadap pertumbuhan diameter.

INTRODUCTION

Hopea gregaria V. Sl. (local name : Balau pooti, pooti) finds its origin in Wowosungu, an island near Kendari South East Sulawesi. This species is found in a dry habitat, stony or clayish soil in hilly land at 20- 300 m above sea level. The tree has a straight bole, the wood has a specific gravity of 1.05 with durability class I, it is resistant to pest and deseases and good for house construction. It has

*) Funded by KEEC Japan under joint project KEEC-UGM

**) Researcher and Instructor, Fac. of Forestry GMU, Yogyakarta.

good natural regeneration therefore it is very potential for reforestation programme.

There are some *Hopea* sp that are naturally found in Indonesia namely : *H.dalosa V. Sl.* (Balau mata kucing) from Malili Sulawesi; H.gregaria, H. sangal (Cengal), *H. mengerawan Miq* (Merawan), H. bancana (Bancana), *H. odorata Roxb*, *H.dryobalanoides Miq* (Damar mata kucing) from Sumatera. Some species are naturally found in South Asia such as *H. brevipetiolaris, H. canarensis, H. cordifolia, H. discolor, H. glabra, H.helferi, H. griffithii, H. jacobi, H. jucunda, H.micrantha, H.minutiflora, H.oblongifolia, H.parviflora, H. racophloea, H. shingkeng, H. utilis, H. wightiana* (Suwanda and Tantra, 1970).

Dipterocarp seedlings may only be responsive to fertilizer addition when grown at very low nutrients availabilities, and that ectomycorrhiza infection may be of great importance to seedlings growth under such conditions (Turner *et al*, 1993). Therefore mycorrhiza inoculation becomes very important to stimulate growth.

Some research results showed that *H. odorata* was successfully inoculated by segments of fruiting bodies of *Russula sp, Boletus* and *Scleroderma sp.* and these were found to have a significant effect on the growth of seedlings (Santoso, 1989) and inoculation could increase the accumulation of micronutrients such as Fe, Mn, Cu, Zn and also Al (Santoso *et al*, 1988).

Mycorrhiza formation will be best at low temperatures, especially in the early stage of its development. It is therefore important to keep the environment at lower temperatures : 27 to 30° C (Harley and Smith, 1983). Some other materials can also affect mycorrhiza development such as rice husk charcoal. Rice husk charcoal stimulates mycorrhiza formation in *Shorea smithiana* (Ogawa, 1993).

Considering the information above, it is very important to study the effects of shading, inoculation and organic matter on mycorrhiza formation and growth of *H.gregaria* seedlings. Therefore, this study aims at determining :

1. the effect of shading on the growth of *H. gregaria* seedlings,
2. the effect of mycorrhiza inoculation on the growth of *H. gregaria*,
3. the effect of organic matter on the growth of *H. gregaria*,
4. interactions of the above factors.

MATERIALS AND METHODS

Materials

Seeds

Seeds of *H. gregaria* were collected from the arboretum of the Faculty of Forestry ,Gadjah Mada University at Yogyakarta. The most abundant are found in January or February.

Rice husk charcoal

Rice husk were collected from a rice mill in Yogyakarta. Rice husk then were processed in the rice husk charcoal kiln for about one day. After two days in the ordinary temperature (room temperature) then rice husk charcoal could be used for this experiment.

Soil inoculum

Soil inoculum was collected from natural stands of Dipterocarps in Bukit Suharto, East Kalimantan. Soil was air dried and brought in net container to give better aeration and lower temperature during transportation.

Organic matter

Organic matter was collected from natural decomposed cow dung. It needs longer decomposed cow dung periode, especially there was no color of cow dung in that organic matter.

Place of the experiment

The experiments were conducted at the Glass house and Screen house of the Faculty of Forestry, Gadjah Mada University. The size of green house was 5 x 4 m with good aeration and screen house was 5 x 4 m.

Methods

Preparation and Inoculation

Seed germination

Seeds of *H.gregaria* were germinated in pots of sterile soil. Soils were collected from Karanganyar area (Central Java) with a pH of 5.7. The type of that soil is latosol.

Rice husk charcoal treatment

Rice husk charcoal with dosages of 0, 10, 20 and 30 grams per pot per seedling were used for treatment.

Organic matter

Organic matter levels were 0, 25, 50 and 100 grams per seedling. Organic matter were mixed together with rice husk charcoal before using as media.

Inocula

Inocula were taken from the soil of Bukit Suharto and the content of mycorrhiza mycelia, sporocarp or root pieces is within the range of 0, 10 and 20 grams per pot. Inocula were kept in lower temperature during transportation and in a room temperature during preparation.

Soil sterilization

Soils were sterilized under sun exposure about one month in the green house at a maximum temperature of 45° C. Thin layer of soil during sterilization is necessary to make better result.

Cultural treatment

Watering. This was done at 8.00- 8.30 am and 4.00- 4.30 pm by an automatic sprinkle. Neutral water (pH 6-7) are necessary to give optimum mycorrhiza development.

Weeding

Weeding was done whenever necessary. This important especially to reduce the pest and deseases and also to give better aeration.

Data Collection

Height and diameter of seedlings were measured twice. Growth were measured at the end of the experiment minus at the begining of the experiment.

Duration of the experiment

The experiment was conducted for 7 months.

Data Analysis

The factorial 4 x 4 x 3 experiment in RCBD was employed for this experiment. There were two experiments, one in glass house and another one in screen house with five blocks, in each experiment. Total seedlings used were 480 seedlings. Organic matter used was four levels, rice husk dosage was four levels and inoculation was three dosages.

Growth of height and diameter were subjected to analysis of variance and F test to determine the effect of various treatments. The Duncans Multiple Range Test was used to compare treatment means if F test was found significant.

RESULTS AND DISCUSSION

Analysis of variance (Table 2) of the screen house experiment shows that there is no significant effect of rice husk and inoculation on diameter growth. However, diameter growth was significantly affected by organic matter. Comparison of means by Duncans Multiple Range Test (Table 3) shows that control treatment produced the smallest diameter of seedlings than organic matter treatments. 100 grams organic matter produced the biggest diameter than other treatments.

Organic matter had more nutrient available such as nitrogen, phosphate, calcium and micronutrients. Organic matter also improved soil aeration and therefore made better respiration in the seedlings.

Organic matter decomposition made slowly soluble phosphorus more readily available. The organic materials combined with iron, aluminum and

Table 1. Effect of organic matter, rice husk and inoculation on diameter growth(mm) of *H. gregaria* in screen house experiment

		Organic Matter			
		0 gram	25 grams	50 grams	100 grams
Rice husk	Soil inoculum				
0 gram	Io	1.23	1.31	0.63	1.24
	I1	0.79	1.05	0.97	0.69
	I2	0.56	0.61	0.90	1.27
10 grams	Io	0.92	1.34	0.54	0.95
	I1	0.86	0.71	1.01	1.57
	I2	0.48	1.04	0.84	1.25
20 grams	Io	0.89	0.71	1.05	1.27
	I1	1.04	1.05	0.87	1.01
	I2	0.76	1.51	1.18	0.87
30 grams	Io	0.57	1.14	0.91	1.28
	I1	0.93	0.79	0.84	1.38
	I2	0.83	1.70	0.70	0.94

Note: Io = 0 gram ; I1 = 10 grams ; I2= 20 grams.

Table 2. Analysis of variance of diameter growth of *H. gregaria* in screen house experiment

Source	dF	Sum of Squares	Mean Squares	F value	Pr>F
Block	4	2.1143	0.5285	1.70	0.1513
Org Matter (O)	3	4.4273	1.4757	4.75**	0.0032
Rice husk (R)	3	0.2449	0.0816	0.26	0.8521
OR	9	1.3783	0.1531	0.49	0.8780
Ino (I)	2	0.0506	0.0253	0.08	0.9217
OI	6	2.1613	0.3602	1.16	0.3296
RI	6	1.1497	0.1916	0.62	0.7165
ORI	18	9.0850	0.5047	1.63	0.0573
Error	188	58.3853	0.3105		
Corrected total	239	78.9971			
			mean of diameter 0.97879167		

calcium releasing phosphate anions to be available for faster plant growth (Table 3 and Table 5)

Diameter growth in glass house was significantly affected by organic matter and rice husk (Table 5). However, diameter growth was not significantly affected by inoculation. Comparison of means (Table 6) shows that organic matter of 100 grams gave better diameter growth (4.2353 mm) than 50 grams (2.975 mm). Control mean has the lowest diameter growth (2.728 mm). Organic material decomposition enhances plant nutrition by recycling essential elements used by

Table 3. Effect of organic matter on diameter growth (mm) in screen house experiment

Duncan grouping	Mean	N	Organic matter
A	1.143	60	(100 grams)
A	1.080	60	(25 grams)
B	0.870	60	(50 grams)
B	0.822	60	(control)

Note : N = total sample number.

Table 4. Effect of organic matter, rice husk and inoculation on diameter growth (mm) in glass house experiment

		Organic Matter			
		0 grams	25 grams	50 grams	100 grams
Rice husk	Soil inoc				
0 gram	Io	4.820	5.660	2.480	5.760
	I1	2.160	3.880	2.500	3.220
	I2	2.340	3.440	3.740	4.380
10 grams	Io	3.160	2.700	1.940	2.420
	I1	1.380	1.682	2.680	5.700
	I2	1.080	1.120	1.820	4.200
20 grams	Io	1.980	0.964	3.760	3.140
	I1	5.220	3.600	2.460	3.320
	I2	1.980	6.360	3.940	2.240
30 grams	Io	3.460	3.920	2.100	5.160
	I1	2.580	4.460	4.080	6.800
	I2	2.580	4.120	4.200	4.700

Note : Io = 0 gram ; I1 = 10 grams ; I2= 20 grams

Table 5. Analysis of variance of diameter growth of *H.gregaria* in glass house experiment

Source	dF	Sum of Squares	Mean Squares	F value	Pr>F
Block	4	57.5723	14.3930	1.58	0.1803
Org Matter (O)	3	81.7632	27.2544	3.00**	0.0319
Rice husk (R)	3	78.6404	26.2134	2.88**	0.0370
OR	9	65.4618	7.2735	0.80	0.6163
I	2	1.9590	0.9795	0.11	0.8979
OI	6	34.7679	5.7946	0.64	0.7000
RI	6	62.0748	10.3458	1.14	0.3416
ORI	18	153.7639	8.5424	0.94	0.5313
Error	188	1708.3998	9.0872		
Corrected total	239	2244.4035	diameter mean 3.36220833		

the previous crop plants and making otherwise unavailable nutrients in soil minerals and in mineral compounds more readily available (Table 6)

There is a tendency that rice husk in certain percentage stimulated rooting and increased the root volume and hence plant growth.

Table 6. Effect of organic matter to the diameter growth (mm) in glass house

Duncan grouping	Mean	N	Organic matter
A	4.253	60	(100 grams)
AB	3.492	60	(25 grams)
B	2.975	60	(50 grams)
B	2.728	60	Control

Note: N = total of sample number

Comparison of mean (Table 7) shows that rice husk of 30 grams, 20 grams and control gave better diameter growth (4.013 mm, 3.698 mm and 3.247 mm) than 10 grams of rice husk. 10 grams rice husk probably absorbs some nutrients available and therefore reduces growth. A good percentage of rice husk could enhance plant growth but too much concentration of rice husk might harm the development of roots.

Table 7. Effect of rice husk on diameter growth (mm) in glass house experiment

Duncan grouping	Mean	N	Rice husk
A	4.013	60	30 grams
A	3.698	60	0 gram
AB	3.247	60	20 grams
B	2.490	60	10 grams

Note: N = total of sample number

Ogawa (1989) suggested that the charcoal might become a suitable place for the propagation of nitrogen fixing bacteria, Rhizobium and VAM fungi and also for the growth of plant roots, from the facts that charcoal is in general a porous and alkaline substance with high moisture content and good aeration.

Analysis of variance (Table 8) and comparison of means (Table 9) shows that the glass house experiment resulted in better diameter growth (3.362 mm) than did screen house (0.979 mm). Generally, the early stages of dipterocarp growth was better in screen house due to better mycorrhiza formation at lower temperatures. At low temperatures mycorrhiza formation is better and has better effect on growth (Harley and Smith 1983 ; Suhardi *et al*, 1993 and Suhardi, 1993). In this experiment means of glass house and screen house show different results.

Table 8. Analysis of variance of diameter growth *H.gregaria* in glass house and screen house experiment

Source	dF	Sum of Squares	Mean of Squares	F Value	Pr>F
Exp	1	681.6810008	681.6810008	140.24 **	0.0001
Error	478	2323.4006793	4.8606708		
Corrected total	479	3005.0816801			

Table 9. Effect of shading on diameter growth(mm) of *H.gregaria*

Duncan grouping	Mean	N	Experiment
A	3.362	240	Glass house
B	0.979	240	Screen house

Note: N = total of sample number

Table 10. Effect of organic matter, rice husk and inoculation on height growth of *Hopea gregaria* in screen house

		Organic Matter			
		0 gram	25 grams	50 grams	100grams
Rice husk	Soil inoculation				
0 gram	Io	1.56	1.72	1.59	1.30
	I1	1.83	1.73	1.58	1.85
	I2	2.02	1.75	1.33	1.68
10 grams	Io	0.77	1.16	1.21	1.47
	I1	1.67	1.32	1.97	1.51
	I2	1.82	2.53	1.44	1.35
20 grams	Io	0.97	1.13	2.04	1.10
	I1	1.97	1.52	1.36	1.84
	I2	1.12	1.26	1.40	1.57
30 grams	Io	1.47	1.01	1.14	0.90
	I1	2.65	0.88	2.00	1.87
	I2	1.53	1.49	1.54	1.81

Note: I =Soil inoculation ; Io= 0 gram ; I1 = 10 gram ; I2= 20 gram.

In glass house the growth was 3.362 mm which is better compared to only 0.979 mm in screen house experiment.

Photosynthesis process may have an on effect on production. This species is probably an intolerant species, it therefore needs light since the early stage of its growth. This species is naturally found in Kendari, Sulawesi and seems to have a different response to light intensity compared to dipterocarps which is naturally found in Kalimantan such as *Shorea bracteolata, S. smithiana, S. selanica, Dryobalanops sp* and many others.

Analysis of variance (Table 11) shows that there is no significant effect of organic matter and rice husk, but height growth is significantly affected by inoculation (Table 10 and Table 11). Comparison of means by Duncans Multiple Range Test (Table 12) shows that 10 grams and 20 grams inoculation produced taller seedlings (1.722 cm and 1.603 cm) than did control in screen house (1.285 cm).

Table 11. Analysis of variance of height growth in screen house

Source	dF	Sum of Squares	Mean Squares	F value	Pr>F
Block	4	35.7190	8.9297	14.08**	0.0001
Org Matter	3	0.7618	0.2539	0.40	0.7529
Rice husk	3	1.5235	0.5078	0.80	0.4949
OR	9	5.7754	0.6417	1.01	0.4320
I	2	8.1885	4.0942	6.46**	0.0019
OI	6	6.0748	1.0124	1.60	0.1502
RI	6	3.5219	0.5869	0.93	0.4778
ORI	18	10.5410	0.5856	0.92	0.5512
Error	188	119.2313	0.6342		
Corrected total	239	191.3375	height mean 1.5366		

Table 12. Effect of inoculation on height growth of *H.gregaria* inscreen house experiment

Duncan grouping	Mean	N	I
A	1.722	80	10 grams
A	1.603	80	20 grams
B	1.285	80	control

Note: N = total sample number ; I = inoculation

Analysis of variance (Table 14) shows that there is no significant effect of organic matter and rice husk and combinations of rice husk, organic matter and inoculation. However, height growth was significantly affected by inoculation (Figure 1 and 2).

Comparison of means by Duncans Multiple Range Test (Table 15) shows that inoculation produced significantly taller seedlings (9.608 cm and 9.355 cm) than control (7.305 cm).

Inoculation with soil containing ectomycorrhizal fungi significantly increased shoot dry matter and gave healthier seedlings. Non mycorrhizal seedlings absorbed less phosphate and translocated it more readily to the tops but only for a limited period. In mycorrhizal seedlings translocation to the top was initially slower but was sustained and eventually more phophate moved to the tips than in non mycorrhizal seedlings.

Table 13. Effect of organic matter, rice husk and inoculation on height growth of *H. gregaria* in glass house.

		Organic Matter			
		0 grams	25 grams	50 grams	100 grams
Rice husk	Soil Inoculation				
0 gram	Io	10.00	12.44	6.26	8.54
	I1	10.34	9.60	6.96	10.12
	I2	10.02	9.26	7.96	6.80
10 grams	Io	1.78	5.84	6.12	9.96
	I1	8.72	8.44	10.64	8.10
	I2	8.68	13.78	5.40	5.40
20 grams	Io	4.08	7.92	5.26	11.06
	I1	9.16	8.04	11.18	11.28
	I2	8.76	8.50	6.92	11.06
30 grams	Io	8.10	9.18	8.28	5.06
	I1	13.86	5.78	11.56	9.94
	I2	12.34	8.90	8.24	12.82

Table 14. Analysis of variance of height growth in glass house experiment

Source	dF	Sum of Squares	Mean Squares	F value	Pr>F
Block	4	1174.0690	293.5172	11.07**	0.0001
Org Mt(O)	3	6.2379	2.0793	0.08	0.9716
Rce hs (R)	3	70.4539	23.4846	0.89	0.4498
OR	9	306.1923	34.0213	1.28	0.2487
(I)	2	255.1403	127.5701	4.81**	0.0092
OI	6	194.0594	32.3432	1.22	0.2981
RI	6	141.6325	23.6054	0.89	0.5034
ORI	18	474.3791	26.3543	0.99	0.4690
Error	188	4987.0020	26.5266		
Corrected total	239	7609.1	66780		
			height mean		
			8.7559		

Table 15. Effect of inoculation on mean of height growth in glass house

Duncan grouping	Mean	N	I
A	9.608	80	10 grams
A	9.355	80	20 grams
B	7.305	80	0 gram

N= total sample number ; I = Inoculation

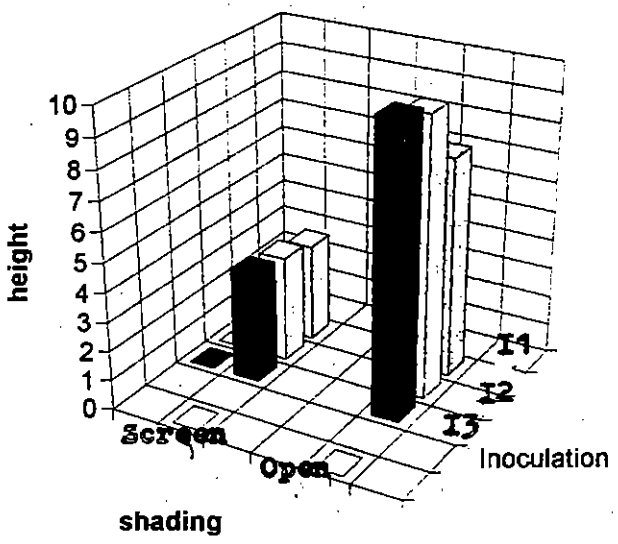

Figure 1. Effect of shading and inoculation on height of *Hopea gregaria*.

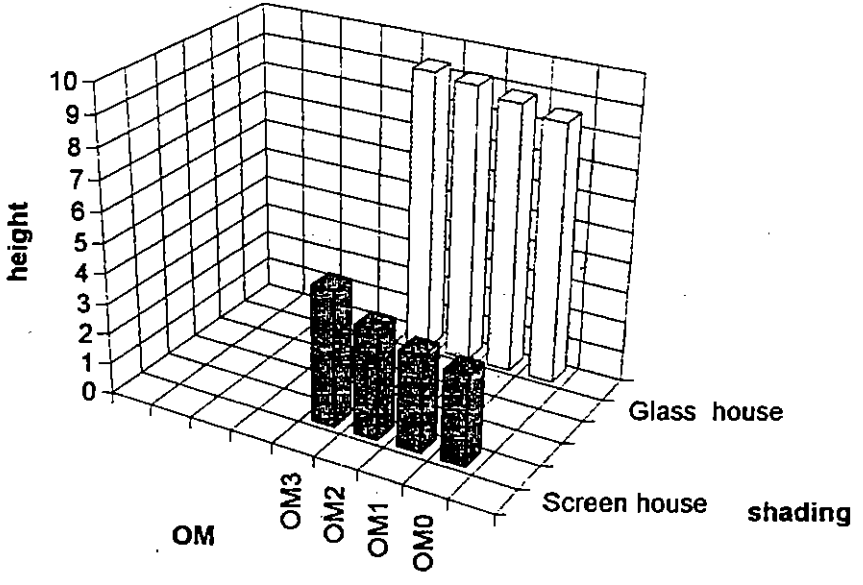

Figure 2. Effect of shading and organic matter on height of *Hopea gregaria*.

Table 16. Analysis of variance of height growth *H.gregaria* in glass house and screen house experiment.

Source	dF	Sum of Squares	Mean of Squares	F Value	Pr>F
Exp	1	6254.252853	6254.252853	383.25 **	0.0001
Error	478	7800.504345	16.39047		
Corrected total	479	14054.757199			

Comparison of means (Table 17) and also in Figure 1 and 2 shows that glass house experiment gave better height growth than did screen house (8.756 cm compared to 1.537 cm). Photosynthesis in glass house was better than in screen house. In general light is essential for the formation of chlorophyll although some plants species develop chlorophyll in darkness. Relatively low light intensities are effective in initiating or promoting cholorophyll formation.

Very bright light in fact causes a net decomposition of chlorophyll. It seems that H. gregaria in glass house had better equilibrium and therefore affected to the photosynthesis production and growth.

Table 17. Effect of shading to height growth of *H. gregaria.*

Duncan Grouping	Mean	N	Exp
A	8.756	240	glass house
B	1.537	240	screen house

Note: N= total sample number

CONCLUSIONS

Diameter growth of *H. gregaria* was significantly affected by organic matter in both screen house and glass house treatments. Rice husk also affected the diameter growth in glass house. However, inoculation had no significant effect on diameter growth.

Height growth was significantly affected by inoculation in screen house and in glass house. However, organic matter and rice husk had no significant effect on height growth. Glass house experiment shows better results in terms of diameter and height growth.

ACKNOWLEDGEMENT

The writer would like to express his gratitude to KEEC - Japan for supporting funds and facilities under Joint Research KEEC-UGM to conduct this research. He would like to express his sincere thanks to the Dean of the Faculty

of Forestry for this opportunity. Thanks are also extended to Prof Oemi Haniin S,Prof Soenardi P and the Board of Editors for sacrificing their time to review this paper.

LITERATURE CITED

Harley, J.L. and S.E. Smith 1983. Mycorrhizal symbio sis.Academic Press.

Mori Shigeti and Marjenah. 1993. Effect of wood charcoal and charcoal rice husk on the growth of Dipterocarp trees with special reference to ectomycorrhiza formation in Esat Kalimantan. BIO-REFOR Proceedings of Yogyakarta workshop 1993. BIO-REFOR/IUFRO/SPDC.

Ogawa, M. 1993. Report of short term research cooperation on ectomycorrhiza of dipterocarps and the utilization for reforestation JICA-9(a)- 137. PUSREHUT, East Kalimantan.

Santoso, E. 1988. The effect of mycorrhizas on the stem diameter and dry weight of dipterocarp seedlings. Bulletin-Penelitian-Hutan 1988. No 504, 11- 21.

Santoso, E, S. Hadi, R. Soeseno and O. Koswara 1988. Accumulation of micro-nutrients by five dipterocarp species inoculated with differ ent species of mycorrhizal fungi. Bulletin Penelitian Hutan 1988, publi 1989 No 514, 11-17; 5 ref Bogor.

Suhardi, E.Faridah, E.Iskandar and Sri Rahayu. 1993. Mycorrhiza formation and growth of Shorea leprosula after using charcoal and rockphosphate in Bukit Suharto in BIO-REFOR Proceedings of Yogyakarta workshop Sept 20 -23, 1993 BIOREFOR/SPDC.

Suhardi. 1993. Effect of fertilizer, charcoal and mycorrhiza inoculation to the growth of Dryobalanops sp in Proceeding National Seminar on peat BPPT.

Supriyanto, I. Setiawan and M. Omon. 1993. Effect of Scleroderma meicistopteryx Ridi seedings in BIO REFOR Proceedings of Yogyakarta workshop of Yogyakarta workshop Sep 20 - 23, 1993 BIOREFOR-IUFRO/SPDC (p: 186-188).

Suwanda, R.A.P and I.G.M. Tantra. 1970. Pengenalan jenis-jenis ekspor serie ke II. Projek Peningkatan Prod dan Pengolahan Kayu bid:Penyusunan Pedoman jenis-jenis pohon ekspor. Kerja sama Lembaga Penelitian Hutan dan Direktorat Pengusa
haan Hutan.

Turner I.M, N.D Brown and A.C. Newton. 1993. The effect of fertil izer application on dipterocarp seedling growth and mycorrhizal infection. Forest Ecology and Management Department of Botany, National University of Singapore.

Yamamoto K. and Hong L.T. 1989. Location of extractives and decay resistance in some Malaysian hardwood species. Journal Tropical Forest Science. Forestry & Forest Products Research Insitute, Tsukuba 305. Japan. 2:1, 61-70.